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HOWARD CREEK FUELS MANAGEMENT PLAN: A CASE HISTORY

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HOWARD CREEK FUELS MANAGEMENT PLAN :

A CASE HISTORY

FINAL REPORT FOR COOPERATIVE AGREEMENT NO. 22-C-3-INT-28-CA, Fire management planning and evaluation in the northern Rockies, with SYSTEMS FOR ENVIRONMENTAL MANAGEMENT.
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Three papers:
Effects of prescribed fire on forest fuel distributions eight and eleven years after burning.

Howard Creek fuels management plan.

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Howard Creek Fuels Management Plan:
A Case Study

Introduction

A fuels management plan is a resource level fire management plan that deals with fuel management needs and opportunities for a specific piece of land. The objective of a fuels management plan is to describe the fuel management options necessary to surrport 1and and resouce management objectives for an area (Fischer, 1977).

This paper illustrates the general process of developing a drainage level fuels management plan, using the Howard Creek drainage on the Lolo National Forest in Region 1 as a case study. Discussion will primarily focus on the methods and techniques available to the fuels management planner, stressing the "how to" aspect of the fuels management planning process.

The traditional approach in forest management has been to consider the management of forest fuels principally in the context of a timber management activity - an "entry" into a managed stand. Efforts directed at the downed woody fuels was done so to reduce the risk of fire associated with the residual slash materials produced by the (harvest) operation, to aid in site preparation, or some combination of the two. Under this philosophy, forest fuels were typically managed only when they occurred as a result of (or prior to) a timber stand entry, usually some type of harvest operation, with both the timing and method of fuel treatments largely dependent upon the type and quantity of timber harvested.

As the concept of fire management, as opposed to fire control, gained widespread support within the forestry community, a new philosophy of fuels management also began to emerge. This perspective on fuels management began to view the forest fuel complex as just one component of a forest ecosystem that consisted of many interrelated components. Although the character of the fuel complex often relates to the timber management history of the stand, in many cases (such as in "un-managed" stands) the nature of the fuel complex is simply a product of the natural biomass accumulation-detritus cycle, where insects, disease and natural mortality factors serve as the driving forces affecting the rates of accumulation and decay.

The "natural" as well as the "managed" fuel complex then came under the scrutiny of foresters and fire managers responsible for assessing the relative fire danger risks and ecosystem effects associated with varying levels of forest fuel accumulations. The concepts of "risk" and resource valuation concurrently evolved from the traditional viewpoint that associated 'stand values' principally with timber production potentials to a viewpoint that sets values based on a relative mix of the resources present and used.

In this light the need for fuels management planning conducted independently of commodity-oriented forest management activities became more apparent. This paper attempts to present fuels management planning from the perspective of representing both a response to a need associated with a particular forest management activity (eg: timber harvesting or wildlife habitat improvement) and also as a tool to meet management objectives not

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primarily associated with direct commodity revenues (wilderness, long-term hydrologic and soil stability, visual quality objectives etc.) In these cases the benefits accrued to other commodity-oriented resources may be of secondary importance.

An example of this latter case would be when the primary objective is to maintain (or attempt to return to) a "natural" fuel complex, such as in a non-roaded or wilderness areas. A fuel treatment such as a prescribed burn may be performed which achieves the "natural" fuel complex objective but may or may not have a positive effect on other resource objectives lower in priority.

In addition, this philosphy of fuels management recognizes that the nature of the fuel situation present in a stand may often dictate and/or limit what management options are feasible for the stand; for this reason alone it is important to make relevant information on the fuel situation available to managers to serve as input when planning management activities.

Due to the nature of the resource objectives in the Howard Creek area, the primary goal for fuel management in this drainage will be to meet commodity-oriented objectives (production of forest products) such as general hazard abatement, timber site preparation needs, and production of fuel heating wood for local residents.

Components of a Fuels Management Plan

Prior to developing the fuels management plan, the following types of information should be assembled for the planning area :

- Fire History
- Fire Weather
- Fuel Appraisal
- Fire Effects

Information on these fire related elements collectively defines the fire situation for the planning area, and thus largely influences the choice of fuel management options available to meet the management objectives described in the forest management plan. This data also helps the manager determine risk and valuation priorities, and describes the fire ecology and fuel complex attributes in a way that facilitates coordination between fire management and other resources.

Frequency tables were compiled for various stand parameters to help provide information on the range of occurrence of these parameters. Tables are included for S.A.F. cover type, Montana Habitat Type, fuel loading classes, fire potential adjective ratings, fuel models, and management areas described in the forest plan for the drainage.

Once the above information is organized for the area, the fuels management plan itself can be prepared. It typically consists of the following major components (Fuel Management Planning Guidelines, 1977) :

- Fuels Management Needs and Opportunities
- Fuels Management Alternatives
- Evaluation and Selection of Alternatives
- Proposed Projects and Planned Accomplishments

These elements will be discussed in relation to the fire situation present in Howard Creek, in the context of the overall management direction established in the proposed Lolo National Forest Plan. A brief description of the Howard Creek drainage and ecological makeup is included below to give an overall perspective of the area.

Area Description

Howard Creek on the Lolo National Forest in western Montana is located about 25 air miles from Missoula, Montana. This drainage is a tributary of Lolo Creek and the Bitterroot river and is approximately rectangular in shape, approximately 3 miles (N-S direction) by 6 miles (E-W direction). In contains approximately 309 stands, totalling 3687 acres. Elevations in the drainage range from 3,900 feet (1,190m) to 5,800 feet (1,770m). The land ownership in the area follows a checkerboard pattern with alternate USDA Forest Service (about 1/2 of the land) and the remainder in private timberland owned by Champion International (Finklin, 1978).

Resource Management Objectives and Emphasis

The overall management direction for this drainage is contained in the Lolo National Forest Plan currently under review. For the purposes of this paper, the management objectives for the Preferred Alternative (shown on Map D of the Forest Plan) will be referred to.

There are three main management emphases which apply to the Howard Creek drainage under the current preferred forest plan alternative:

Management Emphasis	Emphasis Description
Timber / Range	Lands of varying physical environments which are classified for timber production; management provides healthy stands of timber and optimizing timber growing potential and sustained timber production while maintaining soil productivity on steeper slopes.
Wildlife/Other	Lands designated primarily for wildlife including lands generally on south-facing slopes that are winter range for deer, elk, and bighorn sheep and will be managed with timber harvest and/or fire to enhance winter range values; plus lands evenly distributed across the Forest in all site conditions to provide old age stands of timber for old-growth dependent wildlife species with timber harvest employed to maintain or improve old-growth habitat; and critical elk summer habitat including features such as wallows,

mineral licks, seeps and trampled areas in close proximity to important forage units; classified as suitable for timber production.

Visual — Lands with moderate to high visual sensitivity, visible from or adjecent to major roads, trails, communities, and other high use areas; classified as suitable for timber production with a visual quality objective of Retention or Partial Retention.

The three broad management directions above are further broken down in the Proposed Lolo National Forest Management Plan into more specific Management Area types. Those occurring within the Howard Creek Drainage are shown below to illustrate the type of management area information available from forest plans. A short narrative description and goal statement is included for each management area.

Management Area 15

Description — This management area consists mainly of lands that are habitat type 0 (open grassland) with slopes less and 40 percent. Most of this management area occurrs within livestock grazing allotments and currently provides livestock grazing opportunities.

Goals
- Provide for increasing or at least maintaining available forage for livestock grazing while providing for other resource values.

Management Area 16

Description — This management area consists of lands of varying physical environments as determined by soil, slope, aspect, elevation, physiographic stie, and climatic factors, which are suitable for timber management. Habitat groups 1 and 5 with sensitive to nonsensitive soils are represented in this management area.

Within this area are the channels, banks, and lands immediately adjacent to first and some second order streams. These streams are recognized as having generally intermittent flow and the drainage being relatively narrow with a characteristically "V" shape cross section as opposed to the wider bottomed, higher order streams. While they provide limited, if any, fish habitat, they are the headwater streams where high quality water first surfaces to be transmitted through the entire stream system.

Goals
- Provide for healthy stands of timber and optimize timber growing potential.
- Develop equal distribution of age classes to optimze sustained timber production.

- Provide for dispersed recreation opportunities, wildlife habitat, and livestock use.
- Maintain water quality and stream stability.

Management Area 18

Description — This management area consists of lands primarily located at elevations below 5000 feet on south facing slopes. These lands are winter range for deer, elk, and bighorn sheep, generallyt including habitat groups 1,2 and 3 with inclusions of habitat group 4. These lands will be managed to attain a proper balance of cover and forage for bog-game through regulated timber harvest.

Goals
- Optimize forage production and cover for deer, elk, and bighorn sheep on winter range.
- Considering the needs of big game, maintain healthy stands of timber and optimize timber growing potential.

Management Area 19

Description — This management area consists of predominantly shrub lands located at elevations below 5000 feet on south-facing slopes. This land is generally in Habitat group 0, with inclusions of 1,2,3 and 4, and are identified as being important deer, elk and mountain sheep winter range and unsuitable for regulated timber harvest. Historically, fire has played a major rolein providing for the needs of big game in areas represented in this management area.

Goals
- Optimize deer elk, and sheep winter range
- Provide opportunities for dispersed recreation

Management Area 21

Description — This management area consists of a variety of forested lands representing all elevations, aspects, habitat groups, and growing site conditions. They are located throughout the Forest in such a way as to evenly distribute old age stands of timber for wildlife species dependent on old growth for habitat. Wildlife species are represented by species such as the pileated woodpecker, pine marten, hermit thrush, and goshawk.

Goals
- Provide for old-growth succession in timber stands with an optimum arrangement of habitat components to maintain viable populations of old-growth dependent wildlife species.
- Provide opportunities for non-motorized dispersed recreation.

Management Area 23

Description — Management area 23 consists oftimbered lands located primarily at elevations below 5000 feet on south-facing slopes, and with medium visual sensitivity. These lands are important winter ranges for deer, elk, and bighorn sheep, and generally include habitat groups 2,3 and 4. The lands area adjacent to or visible from major roads and trails, communities, and other high use areas.

Goals

- Achieve the visual quality objective of partial retention
- Provide optimal cover/forage ratios for deer, elk, and bighorn sheep winter range with the constraints of goal 1
- Maintain healthy stands of timber within the constraints imposed by goals 1 and 2.

Management Area 25

Description — Management area consists of lands with a medium degree of visual sensitivity and which are available for varying degrees of timber management. These lands have a range of physical environments as determined by soil, slope, aspect, and elevation, physiographic site, and climatic factors. Habitat groups 1 through 5 with sensitive to nonsensitive soils are represented in these lands which are located along jahor roads, trails, communiteis, other high use areas, and a small number of less sensitive viewpoints.

Goals

- Achieve the visual quality objective of partial retention
- Provide for healthy stands of timber and optimize timber growing potential within the constraints imposed by goal 1, while providing for dispersed recreation opportunities, wildlife habitat, and livestock use.

The following frequency table illustrates the distribution of use emphases in the Howard Creek drainage under the proposed Lolo National Forest plan by stand. Timber management activities are emphasized on well over half of the drainage.

Table 1
Frequency of Lolo NF Forest Plan Management Area Occurrence
By Howard Creek Stand

Management Area Description	Code	FREQUENCIES Absolute	Relative
Livestock Grazing Emphasis	15	1	0.003
General Timber Management	16	129	0.417
Wildlife with Timber Mgmt	18	90	0.291
Wildlife without Timber Mgmt	19	4	0.013
Old Growth Emphasis	21	8	0.026
Winter Range	23	37	0.120
Timber	25	40	0.129
7 TYPES IN		309 Cases	

Ecological Makeup of Howard Creek

Data from Oberheu (1978) and the Timber Stand Inventory database was accessed to provide an indication of the range of cover types and plant communities present in Howard Creek. Ten Society of American Foresters (S.A.F.) cover types are found in the Howard Creek drainage. The distribution of these cover types by stand is shown in the table below:

Table 2
S.A.F. COVER TYPE FREQUENCIES

S.A.F. Cover Type Description	Code	FREQUENCIES Absolute	Relative
Englemann spruce/Subalpine fir	206	40	0.320
Interior Douglas fir	210	11	0.088
western larch/Douglas fir	212	17	0.136
grand fir/western larch/Douglas fir	213	7	0.056
ponderosa pine/western larch/Douglas fir	214	12	0.096
lodgepole pine	218	18	0.144
western hemlock	224	1	0.008
western red cedar/western hemlock	227	13	0.104
western red cedar	228	1	0.008
Interior Ponderosa pine	237	5	0.040
< 10 > Classes Observed From		125 Cases	

Montana habitat types (Pfister et al, 1977) in the Howard creek drainage range from the warm dry Douglas fir types to the cold, moist subalpine fir types. A frequency distribution of habitat type occurrences in 309 Howard Creek stands is found below.

Table 3
Montana Habitat Type Occurence in Howard Creek Stands
Source: Timber Stand Database

Montana Habitat Type Series ¦ Type ¦ Phase	Code	FREQUENCIES Absolute	Relative
PSME/AGSP	210	4	0.013
PSME/VACA	250	10	0.032
PSME/PHMA	260	127	0.411
PSME/VAGL	280	42	0.136
PSME/VAGL/ARUV	282	5	0.016
PSME/VAGL/XETE	283	4	0.013
PSME/LIBO	290	7	0.023
PSME/SYAL	310	29	0.094
PSME/CARU	320	35	0.113
PSME/CARU/CARU	323	1	0.003
ABGR/XETE	510	1	0.003
ABGR/CLUN	520	2	0.006
ABLA/CLUN	620	16	0.052
ABLA/LIBO/VASC	663	1	0.003
ABLA/MEFE	670	7	0.023
ABLA/XETE	690	17	0.055
ABLA/VASC	730	1	0.003
17 Types In	309 Cases		

Information Needs

An initial step in the process is to develop a map of the planning area, for which sub-units broken down by management objectives (keyed to the forest plan management areas for the drainage) are shown. Aerial photos for the area provide a valuable resource to for additional detail. Examples of maps for the Howard Creek drainage appear in the Appendix of this report.

Data sources, methods available to obtain the data, and a summary of results for each of the following information areas is found below:

Fire History
Fire Weather
Fuels Complex Appraisal
Potential Fire Behavior
Fire Effects

Level of Data Resolution

Determining the appropriate level of data resolution is an important issue because it can greatly influence the time and cost of developing the plan. Different levels of resolution may be appropriate for each of the areas listed above. In general, the scope of data collection to strive for in a given area should correspond to how that level of information contributes to the objectives stated in the fuels management plan.

Howard Creek Fire History

Fire history data for the previous 50 - 70 years is helpful to review for the purpose of establishing a perspective on how fire has historically functioned in the area.

Sources

Sources for fire history information include historical maps, field reconnaisance, and consultation with individuals knowledgeable in the local areas fire history.

Methods

The principle methodology in use by the USDA Forest Service in Region 1 today for determining the fire history of an area is documented by Arno and Sneck (1977). It involves subjectively sampling the planning area for trees bearing fire scars, obtaining sample wedges from each tree, and establishing a fire chronology on the basis of recorded fire scar dates. An alternative method proposed by Arno and Sneck involves increment boring a sample of trees to establish age-class groups initiated by stand-replacing fire episodes.

Both of these methods represent fairly intensive, and often expensive, approaches; they are typically used when a higher resolution of fire history data is needed to achieve the projects objectives. The objectives of most drainage level fuels management plans will probably not warrent an extensive fire history survey.

Fire History Summary

The last major stand replacing fires in the Howard Creek drainage occurred during the 1910 burn, and a fire in 1917 that covered most of the drainage (Arno, 1985). Smaller, localized fires (lightning fires less than 1/4 acre) have occurred in the area, characteristic of the typical summer time pattern in western Montana. These fires have not greatly affected the overall character of the stands. In stands which have experienced major stand replacing fires, it may be helpful to make a map overlay showing the location and extent of these fires.

Howard Creek Fire Weather

Sources

There are several sources of fire weather data helpful in the preparation of fuels and fire management plans. The most applicable to forest level planning is the archived AFFIRMS station weather data contained in the National Fire Weather Data Library (NFWDL) maintained at the Fort Collins Computer Center (FCCC) on the Univac 1100 series computers. An alternative source for general weather information, useful for longer term statistics, is the National Weather Service from the NOAA (National Oceanic and Atmospheric Administration).

In the near future, as Remote Area Weather Stations (RAWS) become more prevalent, managers will have the capability of accessing very site specific weather data and having summaries of this data made available much as AFFIRMS data is now. About 100 of these stations were installed in the United States as of 1983 (Finklin, 1983). A drawback of some current RAWS applications is that no standards have yet been set for sampling frequency or archiving the data. Since RAWS data is transmitted as it occurs, it is usually lost after being transmitted to the host station unless some type of storage facility is in use.

Methods

Although there are a wide variety of ways to retrieve subsets of these data for a planning area; two of the more commonly used systems are the RX-Weather system and program SUMMARY, which together provide a comprehensive fire weather summary and report facility. Both of these systems are maintained at the FCCC and are accessible through local networks. The choice of which stations weather data to access is also an important one; the station(s) selected should be as "climatically representative" of the planning area as possible. For remote areas not located "climatically close" to established weather stations for which data is available, data from stations that share as many common geographical attributes should be used.

Fire Weather Summary

The climatic parameters that most affect the spread and containment of fires are :

Precipitation (distribution, duration, and amount)
Temperature
Relative Humidity
Wind (speed and direction.

In addition to these, it may be helpful in the case of a project specific fuels management plan to also obtain statistical summaries on at least two of the National Fire Danger Rating System (NFDRS) indices, the energy release component (ERC), and the burning index (BI). Most often, data summaries of NFDRS component indices are found in the forest fire management plan and supporting documents.

For the Howard Creek drainage, a monthly summary of selected weather statistics from the Powell Ranger Station (Finklin,1978) is shown.

Table 4
Mean Monthly Weather Parameters for Powell Ranger Station

Precipitation (inches)

	Mean	Std Dev.	Median
June	2.924	1.171	2.700
July	1.115	0.584	1.110
August	1.380	1.354	1.070
September	2.613	1.862	2.520

Temperature (degrees F)

	Mean	Std Dev.	Median
June	69.1	3.5	68.0
July	80.6	3.6	80.0
August	78.4	5.4	78.0
September	65.9	5.6	66.0

Relative Humidity (%)

	Mean	Std Dev.	Median
June	44.3	7.0	44.0
July	31.0	7.0	31.0
August	33.5	10.0	33.0
September	48.0	9.3	47.0

The average wind speed for the fire season at the Powell Ranger Station site is 5 mph, predominantly from a westerly direction. Winds throughout the Howard Creek drainage, like most mountainous areas, vary considerably with the physiographic microsite, season, and diurnal period. Peak occurrence of lightning storms in July and August, often with little rainfall, leads to increased ignition risk to the drying forest fuels (Finklin, 1978).

Howard Creek Fuel Appraisals

Source

Sources of information on fuel models, loadings, and distribution is obtained either from direct sampling, using the techniques discussed below, or subjectively using the Photo Series method, also described below.

There are several types of fuels complex descriptors of interest to the fuels management planner, including fuel models and fuel loading. Another important descriptor of the fuel complex is the spatial distribution of the fuels, both vertically (throughout the canopy) and horizontally (throughout the forest floor of the stand).

Methods

The methods used for fuel appraisal will depend on the nature of the project and source of the data; if the stands within the drainage have been included in the Regional timber stand data base, a fuel inventory may have already been completed, and fuel loadings may be available in the database for that stand. Note that the field inventory procedures for stand exams record data on "twigs" (1/4-1") and "branches" (1-3"), and 3"+ sound and rotten material, but omit recording intersects of 0-1/4" fuels. (Region 1 Stand Exam Handbook, 1978). This size class (1 hour time-lag class) is a very important size class contributing to fire behavior estimations, and so the lack of this element in the stand exam data set should preclude use of these results for fire behavior modelling inputs.

There are several major techniques available for assessing the natural and activity fuels complex for a fuels management plan. These include the traditional dead and downed woody fuel inventory (a planar-intersect sampling method developed by Brown, 1974), the Photo Series approach developed by Fischer (1981) and others, and the assignment of fuel models to stands in the drainage (resulting in a fuel model overlay map of the area). A more detailed methodology oriented towards fuel biomass sampling is found in Brown, Oberheu, and Johnston (1982). Fuel loading data (weight per unit area, including a distribution of weight by 3 time-lag fuel size classes) for the planning area provide only part of the information needed to assess the relative potential fire behavior. Other environmental site data (such as weather conditions, slope, and certain chemical properties of the fuels) must also be assessed. Photo Series plots provide a faster and less costly way of assessing the fuel complex and establishing ranges of likely fire behavior parameters.

Dead and Downed Fuel Inventorys

When a separate dead and downed fuel inventory is taken, a minimum of 15 plots per stand should be taken if possible. The sampling technique used most often is systematic (non-random) sampling, locating a series of plot centers at evenly spaced points along a set of parallel line transects in the stand. The sampling density will be a function of the size of the stand, the level of precision required, and the resources available for the job. Transect lengths used should collectively allow for percent sample errors of less than or equal to 15 percent if possible. This method may be problematic in sparse fuel complexes such as the drier Douglas-fir and ponderosa pine cover types, resulting in excessive "zero counts" on transects, which often lead to unacceptable percent standard error. In a fuel appraisal of the tribal Mission Mountains Wilderness , Glassy (1985a) found that using longer transect lengths (connecting contiguous plot centers) for 3" and larger sound and rotten fuels reduced the overall sample error to around 8% in sparse fuel complexes.

Once the inventory samples have been taken, a fuel loading report (usually expressed in tons/acre by 0-1/4",1/4"-1",1"-3", and 3"+ sound and rotten size classes) data can be computed using a number of methods; users with access to the FCCC computer may use the DFINV program. Other mainframe programs available include DFCAL and DEBMOD for stand exam fuel inventory data, and QDEBRIS for timber cruise fuel inventory data (Fuel Management Planning and Treatment Guide, 1981). Users with TI-59 calculators may use a program such as WOODY-II, and users with access to microcomputers may use the WOODY16 system (Glassy, 1985b). Statistics on the large piece sizes, fuel depths, and duff depths are also often available with these systems, provided that the raw measurements have been taken.

Photo Series Plots

Photo Series plots are taken primarily to assess natural fuels, resulting from wind, snow, mechanical breakage, and the falling of trees killed by insects, disease, fire and competition for light and moisture (Fischer, 1981). The technique involves visiting a sample of sites and for each one selecting a Photo and accompanying data sheet from one of three collections (one for ponderosa pine, western larch and Douglas fir cover types, one for lodgepole, Engelmann spruce and subalpine fir cover types, and one for grand fir, western hemlock and western redcedar cover types) which best matches the "scene" where the plot center is located. The information on the data sheets with each photo includes a fuel loading distribution, habitat and cover type classification, and estimations (using a five point subjective adjective rating scale) for fire behavior potential parameters for "average bad" fire weather conditions. The inclusion of potential rate of spread, fireline intensity, torching, crowning, resistance to control, and overall fire potential ratings makes the Photo Series method valuable for obtaining quick and inexpensive fire behavior assessments for the stand.

Fuel Complex Summary

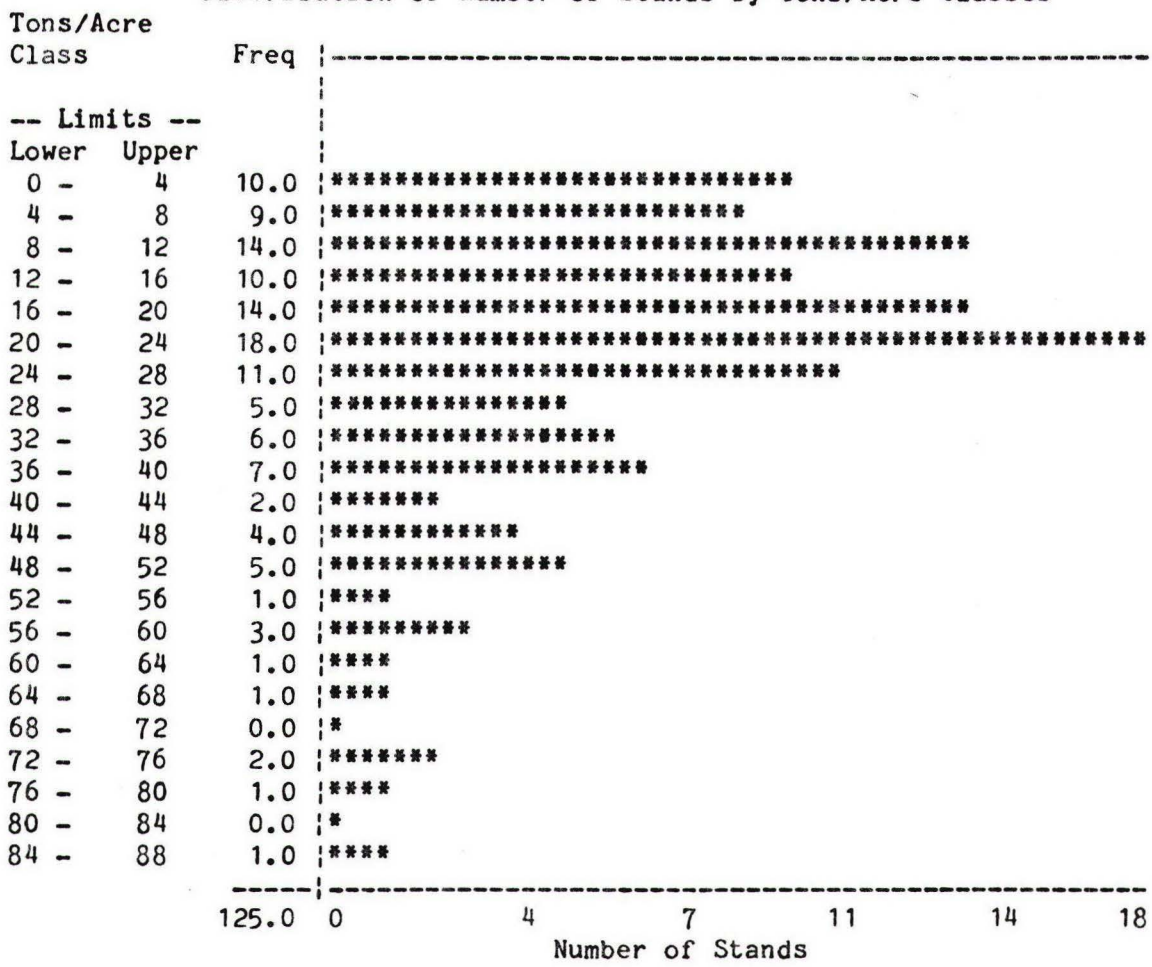
Using the dead and downed fuel inventory method, Oberheu (1978) compiled data for 125 stands in the Howard Creek drainage. A summary of the pooled size class loadings appears below:

Table 5
Howard Creek Fuel Loading Statistics
All Size Classes Pooled
(125 Stands)

Count	:	125			
Mode	:	22.2100	Range	:	83.3700
Minimum	:	1.1100	Maximum	:	84.4800
Mean	:	24.7475	Median	:	20.5300
Std Deviation	:	17.8542	Variance	:	318.7716
Std Error	:	1.5969	% Std Error	:	6.4529

A frequency distribution (using classes of 4 tons/acre) of loadings by number of stands was run to illustrate the relative loading situation in the drainage. It is clear from the plot below that the majority of stands had dead and downed fuel loadings between 1 and 28 tons/acre.

Figure 1
Howard Creek Fuels Management Plan
Distribution of Number of Stands by Tons/Acre Classes



Fire Behavior Potentials

Sources

Data inputs for fire behavior potentials include environmental site factors such as slope, wind speed, temperature, relative humidity, fuel moistures, fuel model (the fire behavior models (NFFL series) should be used, not the NFDRS fuel models), and the fuel loading distribution. Also important for crowning, spotting and torching estimations is the vertical arrangement of fuels in the forest canopy. A crowning key developed by Fahnestock (1970) is commonly used to provide crown fire potentials. A more complete discussion of the inputs required for fire behavior estimations are contained in Rothermal (1983), and Burgan and Rothermal (1984).

Methods

The more common methods of estimating fire behavior potentials include the Photo Series subjective ratings on the data sheets (described in the section on fuel appraisals above), use of a computer fire behavior program such as BEHAVE system on mainframes (Andrews, 1984), and PC/BEHAVE on microcomputers (Bevins and Bradshaw, 1985), and manually using fire behavior nomograms (Albini, 1976).

Fire Behavior Potential Summary

Oberheu (1978) obtained Photo Series estimations for 125 selected stands in the Howard Creek drainage. Definitions of the adjective ratings for the Photo Series fire behavior ratings appear in the Appendix. The frequency of one such parameter, the overall fire potential rating, by stand, is shown below:

Table 6
OVERALL SUBJECTIVE FIRE POTENTIAL RATINGS FOR 125 STANDS

Overall Fire Potential Class Label	Code	FREQUENCIES Absolute	Relative
(missing)		9	0.072
Extreme	E	1	0.008
High	H	12	0.096
Medium	M	57	0.456
Low	L	46	0.368
5 Classes from :		125 Cases	

A drainage hazard map prepared by Oberheu (1978) appears in the Appendix of this report, based on the above overall fire potential ratings.

I also ran a BEHAVE simulation using PC/BEHAVE to illustrate the use of a fire behavior simulation system. With the DIRECT module, a range of potential fire behavior parameters can quickly be determined, using information on the environmental conditions of the stands.

BEHAVE Inputs

To run a BEHAVE simulation, it is necessary to know the fuel model(s) in the stands, representative fuel moistures, the midflame wind speed, slope, and a representative wind direction. To determine the fuel models to use, I examined the following frequency table, computed from data Oberheu compiled in 1978 for the Howard Creek drainage:

Table 7
FUEL MODEL FREQUENCIES

Fuel Model Class Label		FREQUENCIES Absolute	Relative
NFDRS/NFFL	A/01	1	0.008
NFDRS/NFFL	C/02	5	0.040
NFDRS/NFFL	G/10	69	0.552
NFDRS/NFFL	H/08	37	0.296
NFDRS/NFFL	H/10	1	0.008
NFDRS/NFFL	I/13	3	0.024
NFDRS/NFFL	J/12	2	0.016
NFDRS/NFFL	K/11	3	0.024
NFDRS/NFFL	U/09	4	0.032
< 9 > Classes Observed From		125 Cases	

The two most representative models were NFFL 10 (55%) and NFFL 08 (30%), with varying representation among 7 other models. I chose to run a two-fuel model combination, using 60% NFFL 10 and 40% NFFL 08. For windspeeds I used a range of speeds surrounding the mean speed (5 mph) and mode direction (270 degrees) reported by Finklin (1978). The fuel moistures used attempt to represent an "average worst" day in August in Howard Creek. The inputs used for this run were:

Table 8
BEHAVE Fire Behavior Simulation Inputs

DIRECT Module Title		HOWARD CR "AVERAGE BAD" DIRECT RUN				
Dominant Fuel Type		NFFL 10: Timber (Litter and Understory)				
Dominant Fuel Cover	Percent	60				
Secondary Fuel Type		NFFL 08: Closed Timber Litter				
1-Hr Fuel Moisture	Percent	5.0				
10-Hr Fuel Moisture	Percent	6.0				
100-Hr Fuel Moisture	Percent	8.0				
Live Woody Moisture	Percent	110.0				
Midflame Wind Speed	Mi/hr	3.0	4.0	5.0	6.0	7.0
Terrain Slope	Percent	10.0	25.0	40.0		
Wind Direction	Degrees	270.0				
Spread in Max Direction?		Yes *				

The predicted fire behavior parameters resulting from the above inputs to DIRECT are shown below :

Table 9
Howard Cr. Fire Behavior Simulations
for an "Average" Howard Creek Stand

Fuel Model: NFFL 10 (60 Percent)

	Midflame Wind Speed , Mi/hr				
	3.0	4.0	5.0	6.0	7.0
Spread Rate	4.5	6.3	8.4	10.6	13.1
Fireline Int	108.4	152.1	201.3	255.2	313.1
Flame Length	3.9	4.5	5.2	5.8	6.3

Fuel Model: NFFL 08 (40 Percent)

	Midflame Wind Speed , Mi/hr				
	3.0	4.0	5.0	6.0	7.0
Spread Rate	1.2	1.7	2.2	2.8	3.5
Fireline Int	4.4	6.1	8.1	10.3	12.6
Flame Length	0.9	1.0	1.2	1.3	1.4

Weighted Rate of Spread Between:

Fuel Model: NFFL 10 (60 Percent)
Fuel Model: NFFL 08 (40 Percent)

	Midflame Wind Speed , Mi/hr				
	3.0	4.0	5.0	6.0	7.0
Spread Rate	3.2	4.5	5.9	7.5	9.2

Spread Rate Units : Ch/Hr Fireline Intensity Units: Btu/Ft/S
Flame Length Units: Feet

After running DIRECT, I linked to SIZE to provide hypothetical estimates of fire sizes for the modelled fire conditions. The results of the SIZE run appear below:

Figure 11
Howard Creek "SIZE" BEHAVE Outputs

Elapsed Time Hours		Midflame Wind Speed , Mi/hr				
		3.0	4.0	5.0	6.0	7.0
1.0	Final Area	0.5	0.9	1.4	1.9	2.6
	Perimeter	8.8	11.6	14.7	18.0	21.6
2.0	Final Area	2.2	3.6	5.4	7.7	10.4
	Perimeter	17.6	23.2	29.4	36.1	43.2
3.0	Final Area	4.9	8.1	12.2	17.3	23.4
	Perimeter	26.3	34.8	44.1	54.1	64.7
4.0	Final Area	8.7	14.4	21.7	30.8	41.6
	Perimeter	35.1	46.4	58.8	72.1	86.3

Final Area Units: Acres Perimeter Units: Chains

These runs from BEHAVE illustrate how that system can be used to provide general hypothetical fire behavior ranges expected from average conditions. It can also be used for project and site specific applications, by including runs using the DISPATCH, CONTAIN, and SPOT modules. If you have already used the mainframe BEHAVE program to develope and test custom fuel models, the parameters for these can be entered using the FUELS module.

Fire Effects

Sources

Knowledge of fire effects on species within a drainage can be found in the personal experience of resident fire specialists, and in the fire effects and fire ecology literature. There are several sources of fire effects literature which provide generalized fire effects for ecosystems in Region 1. One of the most commonly used is the groupings of Montana habitat types into functionally similar fire groups (Davis et al, 1980) which associates fire succession patterns and fire effects with groups of Montana habitat types. Other sources include the text of the Fire Effects Workshop, Region 1 (1981), and for wildlife and general ecosystem effects, Kozlowski and Alghren, (1974).

Methods

To help provide a description of the fire ecology patterns present in Howard Creek, a list of the habitat type fire groups present in the drainage was made up from the the Montana Habitat Types listed in the earlier section (Ecological Makeup of Howard Creek).

Fire Effects Summary

The 309 stands in Howard Creek for which a habitat type classification was available were placed into five habitat type fire groups. The table below illustrates the distribution, by fire group, of the stands:

Table 10
Howard Creek Fire Group Distribution

Fire Group	Description	Frequency of Howard Creek Stands In H.T. Fire Groups	
		Number	Percentage
04	Warm, dry Douglas-fir habitat types	33	0.106
06	Moist Douglas-fir habitat types	231	0.740
07	Cool Lodgepole Pine dominated habitat types	26	0.084
09	Moist Lower Subalpine habitat types	16	0.051
11	Warm, moist grand fir, western redcedar and western hemlock habitat types	3+	0.019
		309	1.000

The majority of the stands (84%) in Howard Creek fall within the Douglas-fir fire groups, with some inclusions of lodgepole, subalpine, and western redcedar stands. These fire groups (4 and 6) include significant numbers of ponderosa pine and western larch as a seral components. Fire is important in these fire groups as a seed-preparing and stand thinning agent, favoring the pioneer species ponderosa pine, lodgepole pine and and western larch. Davis et al (1980).

Fuel Management Needs and Opportunities

The fuel management needs and opportunities for a drainage are a function of the existing fire situation, the management objectives for the planning area, and the range of fuel management alternatives reasonably available to the fire manager. Fuel management needs are driven by management objectives, but these objectives may or may not be associated with commodity-oriented activities. Fuel management opportunities present themselves in light of on-the-ground conditions that warrent specific actions; they are evaluated in relation to recommended stand treatment needs, and if applied to a managed stand, are often a function of the type of harvest method (if any) previously applied to the stand.

For the Howard Creek drainage, the predominant management objective is to manage for timber production, in some areas with wildlife habitat improvement as an alternative, or co-objective. The primary fuel management needs might be summarized by the following statements :

1) Provide for hazard reduction associated with timber harvest operations This includes slash treatment and, where necessary, removal.
2) Provide concurrently for site-preparation as required by timber plans for the area
3) Reduce to an "acceptable" level potential fire hazards in natural fuel complexes (stands not currently associated directly with timber management activities)

An example of a fuel management opportunity associated with the above needs might include yarding usable timber slash to sites where local residents can pick up the material for fuel wood.

To obtain a list of the current stand treatment needs for the Howard Creek drainage, I queried the Timber Stand Data base for Region 1, selecting on the 309 stands mapped by Oberheu (1978) in Howard Creek. The stand treatment needs are shown below:

Table 11
Howard Creek Stand Treatments

Class Label	Code	FREQUENCIES Absolute	Relative
(missing)	0	18	0.058
No treatment	1	257	0.832
Regenerate Understocked area	2	1	0.003
Regeneration harvest(method unspecified)	3	1	0.003
Precommercial thin	7	30	0.097
Sanitation/Salvage	9	2	0.006
6 Classes Observed From		309 Cases	1.000

The above table indicates that no particular stand treatment is currently planned for 83% of the stands in the drainage, and that about 9% of the stands need precommercial thinning. Only 4 other stands are listed as needed other treatment, ranging from some type of regeneration to sanitation and salvage operations. From the range of stand treatment needs listed above, fuel management treatment alternatives can be developed. Possible fuel management implications from this table are that some type of slash treatment following the precommercial thinning will be needed, such as yarding the small diameter tops out to landing piles for burning or fuel wood utilization.

Fuel Management Alternatives

A small sample of the more common fuel treatment methods and activities are provided below, with average costs/acre for the Lolo National Forest, Region I, which apply to the Howard Creek drainage (Bailey, 1985). A more detailed list of these appears in the appendix:

Fuel Treatment Method/Activity	Cost/Acre
Pre-treatment surveys	2.50
Pre-burn surveys	1.50
Post-burn surveys	1.50
burn dozer piles	16.00
spring broadcast burn (clearcuts +20 ac)	100.00
Understory burn (spring)	80.00
lop and scatter	45.00
wildlife burn (spring)	25.00
hand pile (medium fuels)	350.00
Yard Unmerchantable Material YUM (20-40 tons/acre,cable)	325.00

In an eariler assessment made in the Howard Creek drainage, Oberheu (1978) found that 70% of the stands needed a "condition survey" (equivalent to the pre-treatment survey in the above table), and that 13% of the area could have treatment deferred. The remainder of the drainage was scheduled for either overstory removal, thinning, interplanting, or general rehabilitation. Silvicultural methods at that time used in the drainage included a wide variety of systems, including intermediate cuts, overstory removal, selection cuts, shelterwood cuts, salvage and sanitation cuts, and seed tree cuts. Each of these stand treatments requires a combination of different fuel management activities and methods, evaluated on a project specific basis.

Evaluation and Selection of Fuel Management Methods

The "best" of the feasible alternative fuel management actions for each need and opportunity identified are evaluated in terms of cost, priority assigned to the need, and the degree that the alternative contributes to the overall management objectives for the stand. The following criteria must be considered prior to review and selection of the best method to accomplish the fuels objective (Fuel Management Planning and Treatment Guide, 1981) :

* Fire potential	Fire occurrence, hazard, and weather patterns
* Soils	Effects on erosio8n potential, soil structure, and nutrient content.
* Insects	Vulnerability of treated area to infestation
* Esthetics	Effect on visual quality objectives
* Wildlife	Effect on animal movement, cover, and food production
* Impact on recreaton	Effect on use patterns and site use.
* Reforestation	Effects on site preparation
* Cost	Most economic way to meet desired standards
* Petroleum consumption	Prefer Method which consumes least fuel
* Utilization	Assure that all useful products can be removed before the fuels are treated.
* Air quality	Assure that smoke management guidelines are met.
* Ability to treat	Treatment must be feasible, realistic, and be safe from potential accidents or injuries.

To provide an example for the Howard Creek drainage, assume that the need to provide for hazard reduction associated with an overstory removal operation has been identified as a high priority fuel managment concern. From the range of available fuel treatments and activities (such as a pre-treatment survey), those relevant to the overstory removal for the project area are selected, and the most cost-effective of these are chosen for application at the project. For this example, a pre-treatment survey may be conducted first, followed by decking of all firewood materials at landings for residential uses, with residual materials hand piled and burned.

Proposed Projects and Planned Accomplishments

For the above example, the proposed project area would be coordinated with the timber management activities in the stand, and the following overlay maps would be prepared for the stand map as a minimum:

- Fuel model map
- Stand Hazard map
- Treatment type and boundaries

To help meet utilization objectives, the public would be notified of the time period in which firewood would be made available.

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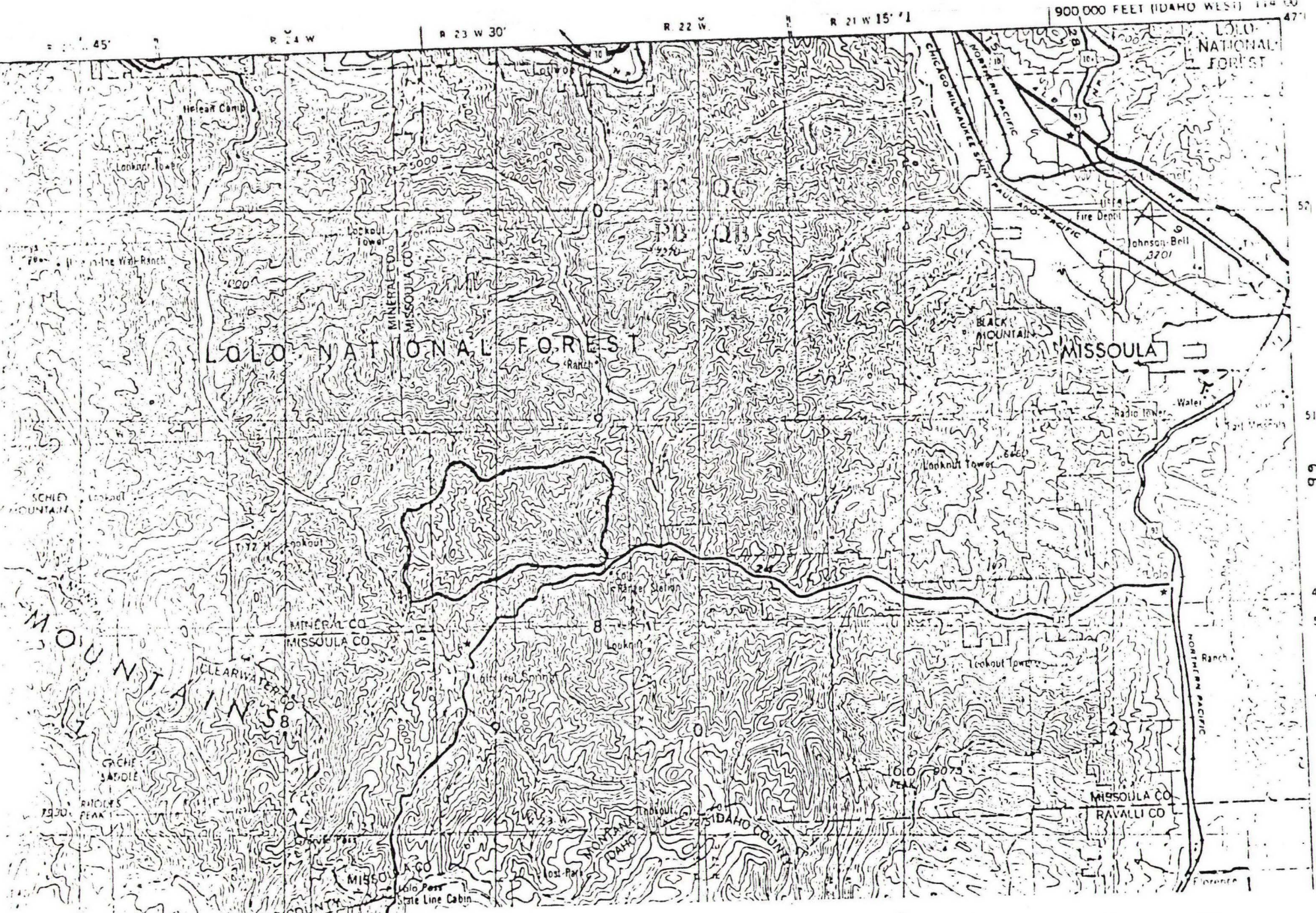


Figure 2.--Topography of Howard Creek drainage (outlined) and surrounding area. Elevation contours are at 200-feet intervals.

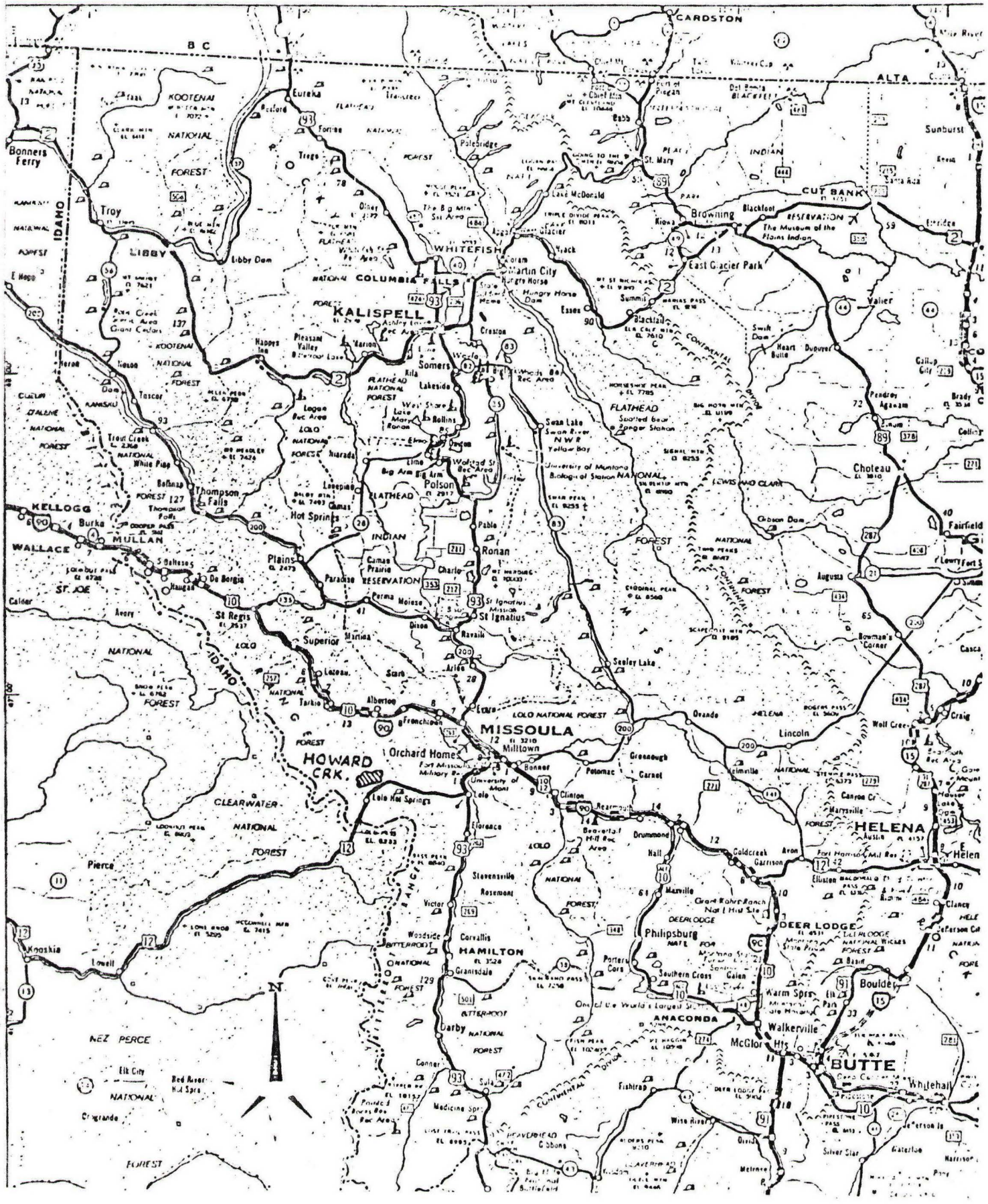


Figure 1.--General location of Howard Creek drainage in western Montana, denoted by shaded area.

~~FIGURE 3~~

APPENDIX B

SUGGESTED DEFINITIONS - FIRE POTENTIAL EVALUATION

Rate of Spread

NIL - Fire can not sustain itself.
LOW - Spread will be slow and discontinuous.
MED. - Uniform spread possible, but can be stopped by aggressive ground attack with hand tools.
HIGH - Spread will be rapid. Indirect attack on fire front may be required for control.
EXT. - Spread will be explosive. Little chance of control until weather changes.

Intensity

NIL - Fire can not sustain itself.
LOW - Cool fire. Very little hot spotting required for control.
MED. - Fire will burn hot in places. Aggressive hot spotting with hand tools likely to be successful.
HIGH - Too hot for sustained direct attack with hand tools. Aerial tankers or large ground tanker required to cool fire front.
EXT. - Direct ground attack not possible. Air or ground tanker attack likely to be ineffective.

Torching

NIL - No chance of torching.
LOW - Occasional tree may torch-out.
MED. - Groups of pole-sized understory trees likely to torch-out.
HIGH - Most of understory and occasional overstory trees likely to torch-out.
EXT. - Entire stand likely to torch-out.

Crowning

NIL - Sustained spread in crowns will not occur.
LOW - Sustained spread in crowns unlikely.
MED. - Some crowning likely but will not be continuous.
HIGH - Sustained crowning likely.
EXT. - Sustained crowning will occur.

Resistance to Control Action

NIL - No physical impediments to line building and holding.
LOW - Occasional tough spots but not enough to cause serious line building and holding problems.
MED. - Hand line construction will be difficult and slow but dozers can operate without serious problems.
HIGH - Slow work for dozers, very difficult for hand crews. Hand line holding will be difficult.
- Neither dozers nor hand crews can effectively build and hold line.

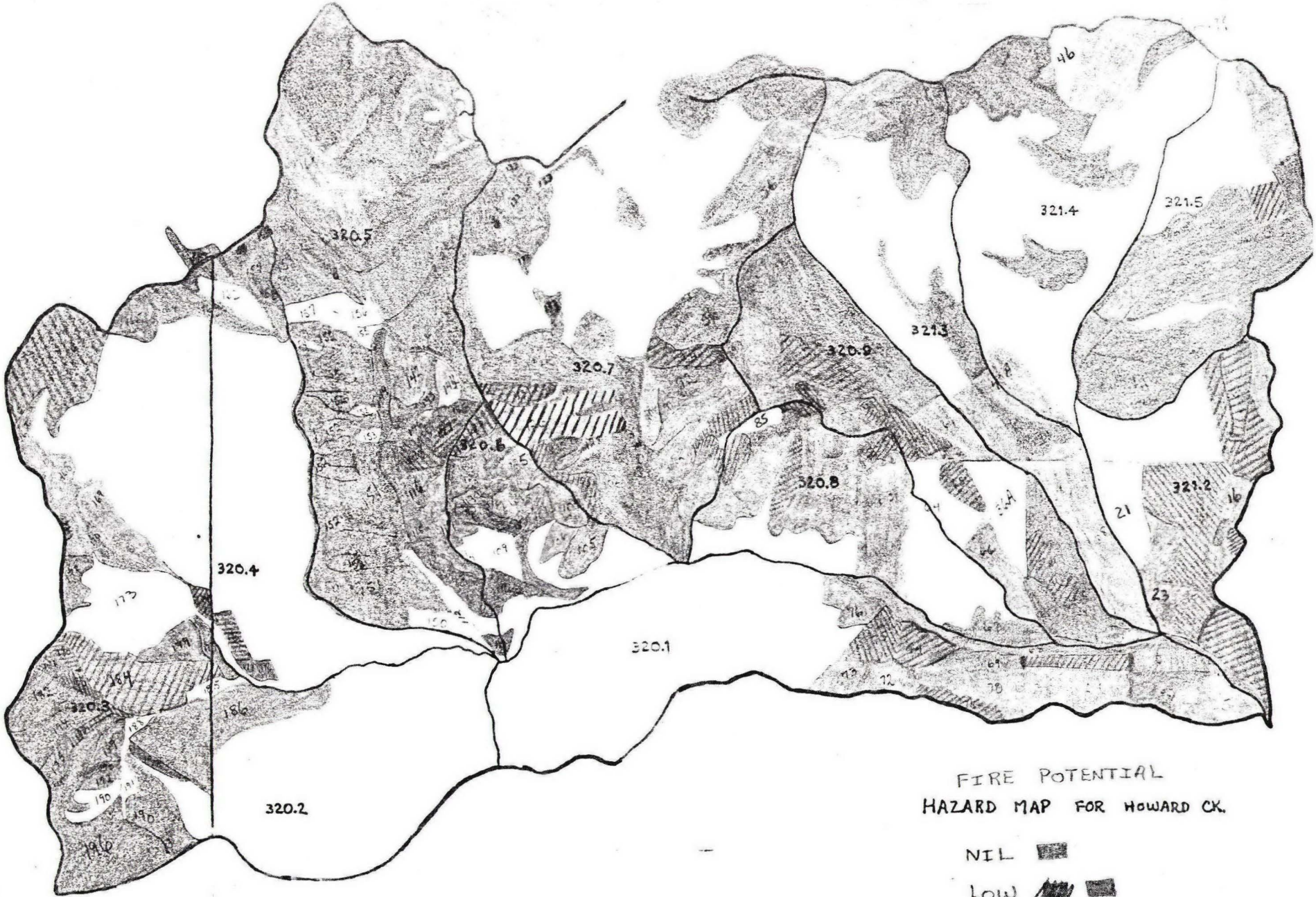
Overall

NIL - Fire will not sustain itself.
LOW - Fire can be easily controlled by several smokechasers with hand tools.
MED. - Aggressive crew-sized (6-10 persons initial attack required for successful control.
HIGH - Aggressive crew-sized (25 persons) initial attack with substantial reinforcement required for successful control. 10% chance that control action will fail.
EXT. - 90% chance that control action will fail.

Appendix D

Fuel Treatment Activities and Methods Used on the Lolo National Forest. Region I

Method	Cost/Acre
slash filter windrows	350.00
pre-treatment surveys	2.50
pre-burn surveys	1.50
post-burn surveys	1.50
slashing (light fuels)	65.00
slashing (medium fuels)	80.00
slashing (heavy fuels)	90.00
machine pile	100.00
burn dozer piles	16.00
burn landing piles/dozer piles	16.00
burn landing piles/front end loader piles	2.76
spring broadcast burn (clearcuts +20 ac)	100.00
summer broadcast burn with Category 1 crews	300.00
Fall broadcast burn (with Category I crews)	200.00
Fall broadcast burn (with Category II crews)	120.00
jackpot burn (fall)	50.00
jackpot burn (spring)	30.00
Understory burn (spring)	80.00
Understory burn (summer. w/ Cat I crew)	450.00
Understory burn (summer. w/ Cat II crew)	300.00
Understory burn (fall, w/ Cat II crew)	250.00
loo and scatter	45.00
wildlife burn (spring)	25.00
wildlife burn (fall)	50.00
spring ecosystem burn (intermediate complexity)	20.00
hand pile (light fuels)	250.00
hand pile (medium fuels)	350.00
hand pile (heavy fuels)	500.00
hand construct fireline (light fuels)	30.00
hand construct fireline (medium fuels)	45.00
hand construct fireline (heavy fuels)	70.00
water bed fireline	54.00
machine fireline (light fuels)	6.00
machine fireline (medium fuels)	10.00
machine fireline (heavy fuels)	15.00
slash removal from leave trees	2.00
yard Unmerchantable Material YUM (12-20 tons/acre)	250.00
yard Unmerchantable Material YUM (20-40 tons/acre.cable)	325.00
yard Unmerchantable Material YUM (40-60 tons/acre.cable)	400.00
yard Unmerchantable Material YUM (40-60 tons/acre.tractor)	160.00
yard Unmerchantable Material YUM (tops only,skidder)	1.50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320.7
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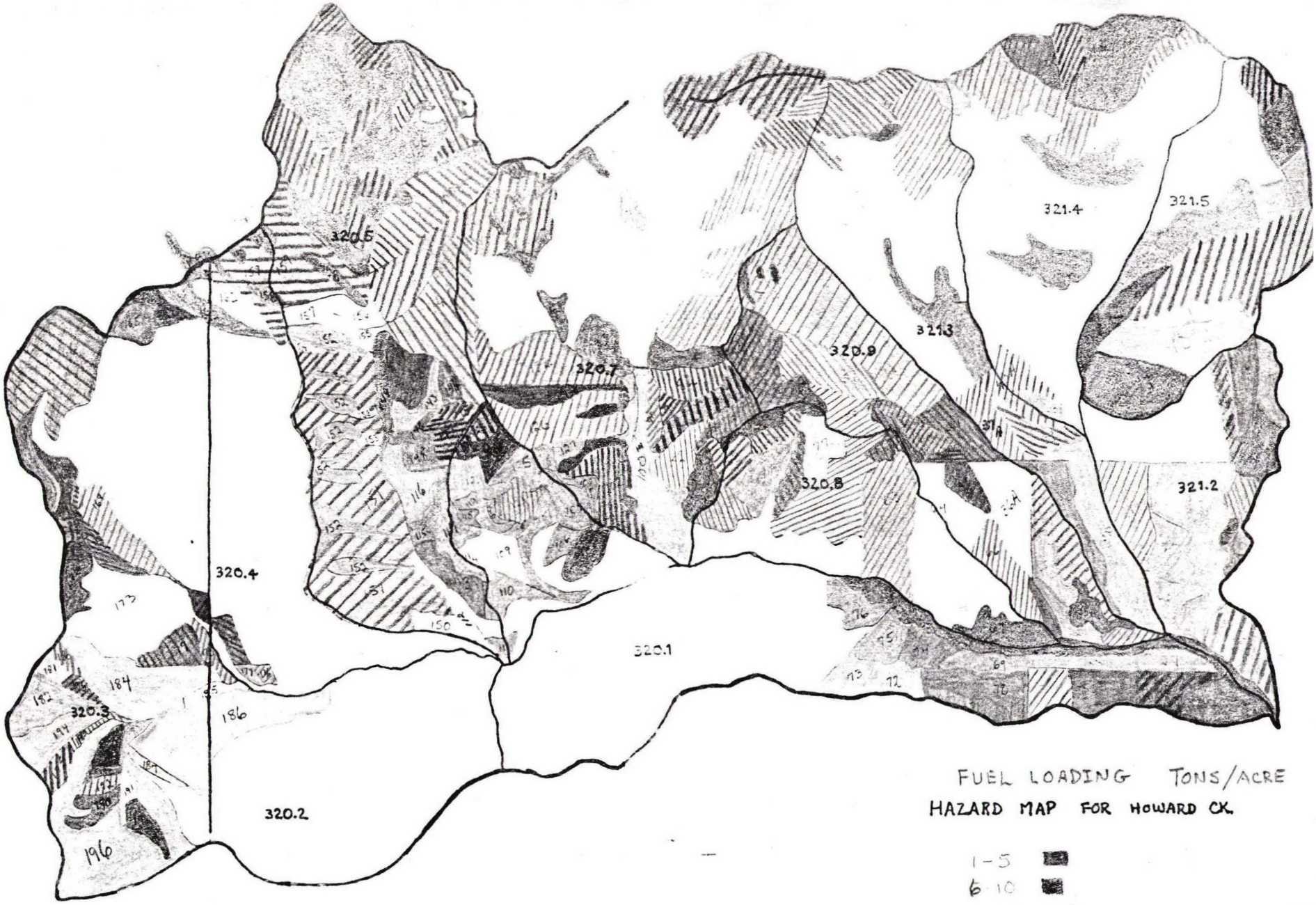
FIRE POTENTIAL
HAZARD MAP FOR HOWARD CK.
NIL
LOW
MEDIUM
HIGH
EXTREME


320.5
320.7
320.9
321.3
321.4
321.5
320.8
321.2
320.4
320.1
320.3
320.2
188 is meadow
FUEL LOADING TONS/ACRE
HAZARD MAP FOR HOWARD CK.
1-5
6-10
11-15
16-20
21-25
26-30
31-35